Methodological Overview of Medical Cost-Effectiveness Analysis

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Objectives

• To provide a background on the rationale for medical cost-effectiveness analysis (CEA)

• To discuss core methodological issues in CEA
  – Role of theoretical foundations

• To introduce important theoretical innovations in cost-effectiveness analysis
Background:
Increases in Health Care Costs

• Nominal Terms:
  – $27 Billion in 1960
  – >$2.5 Trillion today

• As a percentage of GNP:
  – 5% in 1960
  – 18% today
Background: Increases in Health Care Costs

- Since 1960, health care spending has grown by 2.5% more per year than the rest of the economy
- Reasons:
  - Growth in quantity: 1.6% per year
  - Growth in prices: 0.9% per year
- Much of growth in prices is growth in quantity
- Spending rising because we are doing more
- High potential for greater value
Growth in Demand for Cost-Effectiveness Analysis

• Academic medicine
• Government, especially outside the U.S.
  – e.g. in U.S., Office of Technology Assessment, recent CMS, FDA interests
  – e.g. in U.K., National Institute for Health and Clinical Excellence
• Private payers
• Clinicians
• Pharmaceutical companies
  – “Pharmacoeconomics”
Methodological Issues in Cost-Effectiveness Analysis

- Type of analysis
- Perspective
- Definition and measurement of costs
- Definition and measurement of benefits
Type of Analysis

• Cost minimization:
  – Least expensive method to accomplish a fixed objective
  – Problem: assumes objective should be met; objective should be to maximize benefits with available resources

• Cost-benefit:
  – Costs and benefits measured in dollar terms
  – Select all treatments for which net benefit > 0
  – Problem: placing dollar value on outcomes

• Cost-effectiveness: $\frac{\Delta \text{cost}}{\Delta \text{benefit}}$
  – Select treatments with lowest cost-effectiveness ratios
Utility Maximization and CEA

- Max\(_{C,M}\) \(U(C,M)\) s.t. \(I=pcC+pmM\)
- Max\(_{C,M}\) \(U(C,M) + \lambda^*(I-pcC-pmM)\)

First order condition: \(U_C/P_C = U_M/P_M = \lambda\) (utility/$$)

CEA: \(U_M/P_M = \lambda\)

CBA: \(U_M/\lambda = P_M \rightarrow U_M/\lambda - P_M = 0\)

NHB: \(U_M = \lambda P_M \rightarrow U_M - \lambda P_M = 0\)
## Costs and Effectiveness

<table>
<thead>
<tr>
<th>Cost Increases</th>
<th>Effectiveness Decreases</th>
<th>Effectiveness Increases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never do</td>
<td>CEA</td>
<td></td>
</tr>
<tr>
<td>Cost Decreases</td>
<td>Always do</td>
<td></td>
</tr>
</tbody>
</table>

- **Cost Increases**
  - Never do
  - CEA

- **Cost Decreases**
  - CEA
  - Always do
# Cost-Effectiveness of Medical Interventions

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Cost/LY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonatal PKU screening</td>
<td>&lt;0</td>
</tr>
<tr>
<td>Sec. prev. hyperchol. men age 55-64</td>
<td>2,000</td>
</tr>
<tr>
<td>Sec. prev. hyperchol. men age 75-84</td>
<td>25,000</td>
</tr>
<tr>
<td>Pri. prev. mild hyperchol. men age 55-64</td>
<td>99,000</td>
</tr>
<tr>
<td>Screening exercise test men age 40</td>
<td>124,000</td>
</tr>
<tr>
<td>Screening ultrasound every 5 yr. for AAA</td>
<td>907,000</td>
</tr>
</tbody>
</table>
Perspective

- Private
  - HMO, consumer
- Public
  - Medicare, Medicaid, state mental health system
- Societal
  - Include all costs and benefits no matter to whom they accrue
  - Policy analysts (i.e., Panel on Cost-Effectiveness in Health and Medicine)
Benefits

• Specific Outcomes --> General Outcomes
  – Cancers detected
  – Cancers cured
  – Life-years saved
  – Quality-adjusted life years (QALYs) saved
    • Life-years weighted by quality of life weights between 0 (death) and perfect health (1)
    • “Cost-utility analysis”
    • Endorsed by Public Health Service Panel on Cost-effectiveness in Health and Medicine
QALYs

• Total years lived with each year weighted between 0 (death) and 1 (perfect health)

\[ \text{QALYs} = \sum \beta^t S_t Q_t \]
  
  - \( S_t \) survival probability
  - \( Q_t \) quality of life adjustment
  - \( \beta < 1 \) time preference discount factor

• Despite concerns, clearly dominant methodology
  
  - More than 1000 studies
  - Endorsed by U.S. Panel on Cost-Effectiveness Health and Medicine
Methods for Quality of Life Adjustment

• Linear analog scale
• Standard gamble
• Time trade-off
Standard Gamble

\[ Q = p \]
Time Trade-off

\[ Q = \frac{t}{T} \]
Costs: Principles

• Opportunity cost
  – The value of the best alternative which is forgone

• Incremental (marginal) cost
  – The change in costs associated with an intervention
  – Incremental cost-effectiveness (example PAP smears)
## Cost-Effectiveness of Pap Smears

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Increase in LE vs. no screening</th>
<th>Increase in Cost vs. no screening</th>
<th>Average Cost per Life-Yr Saved</th>
<th>Marginal Increase in LE</th>
<th>Marginal Increase in Cost</th>
<th>Marginal Cost per Life-Yr Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 years</td>
<td>70 days</td>
<td>$500</td>
<td>$2,600/LY</td>
<td>70 days</td>
<td>$500</td>
<td>$2,600/LY</td>
</tr>
<tr>
<td>2 years</td>
<td>71 days</td>
<td>$750</td>
<td>$3,900/LY</td>
<td>1 day</td>
<td>$250</td>
<td>$91,000/LY</td>
</tr>
<tr>
<td>1 year</td>
<td>71 days 8 hours</td>
<td>$1,500</td>
<td>$7,300/LY</td>
<td>8 hours</td>
<td>$750</td>
<td>$830,000/LY</td>
</tr>
</tbody>
</table>

Value of 70 days = $9600 vs. Cost = $500
Value of 1 day = $137 vs. Cost = $250
Value of 8 hours = $45 vs. Cost = $750
Role of Theoretical Issues

• Advances in core approaches
  – Uncertainty / value of research
  – Future costs, productivity costs
  – Heterogeneity, self-selection, and empirical CEA

• Dilemmas of welfare maximization
  – Distribution / Arrow Impossibility Theorem
  – Alternate views of CEA exercise (extra-welfarist)

• Practical approach
  – Does it change the answer?
  – Value of promoting discussion (Pauker)
  – D-Day (Arrow)